Population Structure and Tree Health of Flowering Dogwood at Catoctin Mountain Park after 29 Years of Infestation by Dogwood Anthracnose

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This report represents the results of a cooperative project between the USDA Forest Service, Forest Health Protection unit and USDI National Park Service, Catoctin Mountain Park (CMP). The purpose of this project was to assess the survival and health of flowering dogwood (*Cornus florida* L.), an important ornamental and wildlife tree in Eastern North America. This project has been ongoing over the last 29 years. This project has revealed a decrease in the population of flowering dogwoods presumably due to the dogwood anthracnose (Causal agent: *Discula destructiva*). Past surveys conducted in 1984, 1988, and 1994 revealed high levels of mortality, with a clear trend in the decrease of dogwood trees per acre. We estimated a 96% loss in dogwood trees per acre since the first survey was conducted at CMP in 1984. However, the overall tree health of the remaining dogwood appeared to be improving. The results from these surveys suggest that most of the susceptible trees may have died. This survey was conducted to confirm prior findings and to assess the current population levels of this species via comparisons from results of prior studies conducted at CMP.

Background and Introduction:

The flowering dogwood is highly regarded for both its ornamental value and importance as a wildlife tree. The showy springtime display of its petal-like white bracts has made it one of America's most renowned tree species. The clustered, bright red fruit of dogwood, while unsuitable for human consumption, support a wide variety of bird species as well as a large variety of mammals (Halls, 1977). Dogwood tends to be a short shrub (30 to 40 feet tall) with an upper diameter limit of about sixteen inches (Vimmerstedt, 1965). The native range of dogwood extends from extreme southeastern Canada and Maine south to Florida and as far west as Kansas and Texas (Vimmerstedt, 1965). However, over the last thirty years the population of dogwoods has seriously declined presumably due to dogwood anthracnose, caused by *Discula destructive*.

Dogwood anthracnose is thought to be an exotic disease first reported in North America in 1979, although the origins of the fungus are still unknown (Trigiano et al., 1995). The relative resistance exhibited in the Asian dogwood (*Cornus kousa*) suggests that the disease may have originated in Asia. Recent molecular work has suggested a single, recent introduction in to North America (Trigiano et al., 1995). However, the apparent decrease in disease virulence over the last two decades suggests an increase in genetic diversity of *D. destructiva* fungal populations among North American populations (Zhang and Blackwell, 2002). Two species of the genus *Cornus* are susceptible to anthracnose, *C. florida* and *C. nuttallii* (Salogga and Ammirati, 1983). The spread of this pathogen threatens eastern flowering dogwoods across most of its native range, from as far north as Maine, throughout the Appalachians, south to Georgia and as far east as Illinois (Daughtrey, 1994). Spores of *D. destructive* are spread mostly by rain splash (Daughtrey, 1994). However, humans and other animals may disseminate infected fruit and seeds (Britton, 1993). Almost all portions of the tree appear susceptible to disease as *D. destructiva* has been isolated from leaves, flowers, stems, fruits and seeds of infected dogwood trees (Britton and Roncadori, 1993).

Anthracnose severity appears to be affected by humidity, temperature and light conditions (Daughtrey, 1994). Free moisture, in the form of dew or rain are necessary for infection. Disease incidence is often higher during years with higher than average rainfall (Britton, 1993). Secondary cycles of leaf infection

may occur during periods of heavy rains (Daughtrey, 1994). There is an inverse correlation between leaf exposure to sunlight and disease severity, with infection greater in shaded understory trees, in the interior and on the north side of canopies, trees at lower elevations, and in trees with north to east aspects (Daughtrey, 1994). Disease pressure has limited populations of dogwoods to the edges of forest stands, where sunlight, temperature and moisture factors support dogwood growth and inhibit disease infection. While rainfall is conducive to disease infection, it also promotes host vigor and thereby lessens disease impact (Gould, 1994). Trees stressed by drought or winter injury are more susceptible to disease infection.

Leaf symptoms include necrotic lesions surrounded by a reddish or brown-purple zone and necrotic blotches on the leaf tips and along the veins and leaf margins (photo 1) (Hibben, 1988). Leaves infected early in the season usually abscise. Leaves infected late in the season may remain attached until the following spring and are a source of overwintering inoculum (Britton et al., 1993). Rainy conditions will encourage spotting on bracts (Daughtrey, 1994). Twig dieback and epicormic branching are common symptoms of infection (Daughtrey, et al., 1998). Leaf symptoms and twig dieback generally begins in the lower crown and progresses up the tree (Britton, 1993). Infections often progress down the petioles and into shoots, resulting in cankers. Annual cankers often occur on the main stem and lead to twig dieback. Multiple cankers can girdle branches or the main stem and eventually results in tree mortality.

Figure 1. Foliar symptoms of Dogwood Anthracnose (*Discula destructive)* infection. Photo credit: Danielle Martin

This will be the 5th survey conducted at CMP since 1984. Similar surveys were conducted in 1984, 1988, 1994, 2006, and in 2013. The 2006 survey indicated a loss of more than 99% of flowering dogwoods at CMP but the authors felt this may have been due to the methodology. The results from the 2006 survey included data on too few dogwood to allow for meaningful comparisons and so were omitted from the current analyses. However, the small number of trees located appeared healthy. This observation prompted the 2013 survey and the need to alter survey methodology to include more data on trees growing in the roadsides. Even if the Dogwood Anthracnose epiphytotic is over, the long term survival of the dogwood is not secure. Although any apparent losses or mortality evidenced cannot simply be linked to dogwood anthracnose, any analyses investigating a decline for this species needs to consider anthracnose as a critical factor. Other significant factors affecting dogwood health may include anthropogenic factors, other diseases such as powdery mildews, insects and various forms of pollution.

Project Objectives:

The purpose of this project was to document the condition of flowering dogwood at CMP and to compare this data with previous surveys. While survey methods have varied over the past 29 years, all data has been converted into standard measurements (trees per acre, percent of trees in each diameter class, etc.) to allow for comparisons over time.

Methods:

This project was conducted at Catoctin Mountain Park, in Thurmont, Maryland (39.633804, -77.449692). CMP is a 5,810 acre park classified as a Mid-latitude deciduous forest and support a wide variety of tree species, including oaks, hickories, tulip poplars, American beech, maples and eastern hemlocks.

In order to estimate dogwood trees per acre along roadsides at CMP, a complete census of flowering dogwood within 8 feet of the forests edge along every major road was conducted. All live and dead flowering dogwood were counted and positions recorded using a Garmin® 60CSx GPS unit. All field measurements were made in June of 2013. Dogwoods were located from the passenger side of a slow-moving vehicle. In order to assess the health of flowering dogwoods along roadsides, a subsample of 33 individual trees were randomly chosen and assessed for disease severity, as described below.

For each tree, we recorded diameter-at-breast-height (DBH), 4.5 feet above the ground, and trees were placed into one of 5 size classes (<1", 1-1.9", 2-2.9", 3-3.9", and ≥4"). Crown symptoms based on the percentage of crown exhibiting leaf symptoms and/or dieback due to dogwood anthracnose (Class 0 = dead, Class 1 = > 75% foliage affected, Class 2 = 51-75% foliage affected, Class 3 = 26-50% foliage affected, Class 4 = 1-25% foliage affected, Class 5 = healthy) were determined for each tree. Crown symptoms based on the percentage of crown exhibiting leaf symptoms and/or dieback due to powdery mildew (none, low=1-33% foliage affected, moderate=34-66% affected high 67-100% infected) was also determined for each tree.

A trail survey was also conducted in which 4 trails were randomly selected in the park and a census and assessment of disease severity was made within 8 feet of the trails right-side edge. Trail lengths varied between 0.8 and 2.1 miles long. In addition, ten transects 330 feet long by 8.25 feet wide were established in randomly selected adjacent forested areas for comparisons to roadside tree conditions. The location of each transect was chosen by randomly selecting a dogwood that had been along a trail and using that tree for the start of transects. The data from the road survey, trail survey and transects were analyzed individually and also combined to give an estimate trees per acre (TPA) and health of flowering dogwood populations.

To estimate the total number of dogwood from our trees per acre data we used a geographical information system using ArcGIS softwear (ERIS, 2005) to estimate the total number of acres in the park and the proportion of forested and road edge acreages were calculated. CMP is approximately 6,154.0 acres in size. We estimated that 5,996.7 acres of the park are forested in condition. For our analyses of the roadside trees, we estimated 28.4 acres of road conditions by multiplying the length of the road system by road width plus a 35 foot buffer on each side to account for edge effects.

Results:

A total of 184 flowering dogwoods were counted along the major roads within CMP. Using an estimate of 28.4 acres of road area within CMP (including a 35 foot buffer), we calculated 13.5 TPA along roadsides (Table 1). Seven dogwoods were found in 5.6 miles of trails accessed. Only one (dead)

dogwood was found within the ten transects. The trail and transect data was combined to give an estimate of 1.5 TPA within forests (Table 2), for a total of 15 TPA for the entire park. This data was used to estimate a total population of flowering dogwood within the CMP at 9,534 within forests and 383 along roadsides.

An estimate of population levels of flowering dogwoods in dogwood anthracnose disease classes is shown in Figure 2. An estimated loss of 96% total dogwoods has occurred at the park since a 1984 survey (Mielke and Langdon, 1986), a 91% loss since 1988 (Schneeberger and Jackson, 1989) and 82% loss of total dogwoods has occurred since 1994 survey (Sherald et al., 1996).

Tree mortality has fluctuated over time, increasing from nearly 33% in 1984 (Mielke and Langdon, 1986) to 80% in 1988 (Schneeberger and Jackson, 1989). In 1994 tree mortality was only 19% in roadside plots (Sherald et. al, 1996) and in 2013 tree mortality dropped down to 8%. There was an average of 410 total (live and dead) dogwoods per acre in 1984, only 160 per acre in 1988, 83 per acre in 1994 and 15 per acre in 2013.

Average diameter is also decreasing over time (Figure 2). The dramatic decrease in frequency of individuals in the lower diameter classes may indicate low regeneration rates.

Disease severity appears to be decreasing over time (Figure 3). In 2013 the majority of dogwoods (53%) were in disease class 4 and showed relatively low disease levels. Only 3% of trees showed no symptoms of disease, 24% trees were in disease class 3, 13% were in disease class 2 and 3% were in disease class 1. Five percent of trees were dead. The decrease of individuals in the higher disease classes may be a result of mortality of highly infected trees. Remaining trees may be exhibiting some level of resistance to the pathogen.

Frequency of flowering dogwoods in different powdery mildew disease classes and the percentage of population within each disease class are shown in Figure 4. No tree was observed without symptoms of infection of powdery mildew. The majority (63%) of trees were observed in the low powdery mildew disease class, 21% were in the moderate disease class and 11% of trees were observed in the high disease class. Powdery mildew severity was not recorded in previous years.

						Dieback Class CMP Road Data[a]											
Size Class	Count	Prop	Percent of total	Total trees per acre	SE	0	%	1	%	2	%	3	%	4	%	5	%
<1	0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1-2	3	0.1	9.1	1.2	0.5	0	0	0	0	1	33	0	0	2	67	0	0
2-3	10	0.3	30.3	4.2	1.7	1	10	0	0	0	0	1	10	8	80	0	0
3-4	9	0.3	30.3	3.8	1.7	0	0	0	0	3	33	3	33	2	22	1	11
>4	10	0.3	30.3	4.2	1.7	1	10	1	10	0	0	4	40	3	30	1	10
Total	32.0	1.0	100.0	13.4	5.7	2	6.3	1	3.1	4	13	8	25	15	47	2	6.3

Table 1. Flowering dogwood trees per acre by size class and dieback class along roads at Catoctin Mountain Park, 2013. [a]Percent class of tree exhibiting leaf symptoms and/or dieback: 0 = dead, 1 = > 75% affected, 2 = 51-75% affected, 3 = 26 to 50% affected, 4 = 1 to 25% affected, 5 = healthy. Data includes both live and dead trees.

Size class	Count	Prop	Percent of total	Total trees per acre	SE	Dieback Class CMP Trail and Transect Data[a]											
						0	%	1	%	2	%	3	%	4	%	5	%
<1	0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1-2	0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0
2-3	2	0.3	28.6	0.4	0.2	0	0	0	0	0	0	1	50	1	50	0	0
3-4	1	0.1	14.3	0.2	0.1	0	0	0	0	0	0	0	0	1	100	0	0
>4	4	0.6	57.1	0.9	0.3	1	25	0	0	0	0	0	0	3	75	0	0
	7.0	1	100	1.5	0.6	1	14	0	0	0	0	1	14	5	71	0	0

Table 2. Flowering dogwood trees per acre by size class and dieback class along trails and transects at Catoctin Mountain Park, 2013. [a]Percent class of tree exhibiting leaf symptoms and/or dieback: 0 = dead, 1 = > 75% affected, 2 = 51-75% affected, 3 = 26 to 50% affected, 4 = 1 to 25% affected, 5 = healthy. Data includes both live and dead trees.

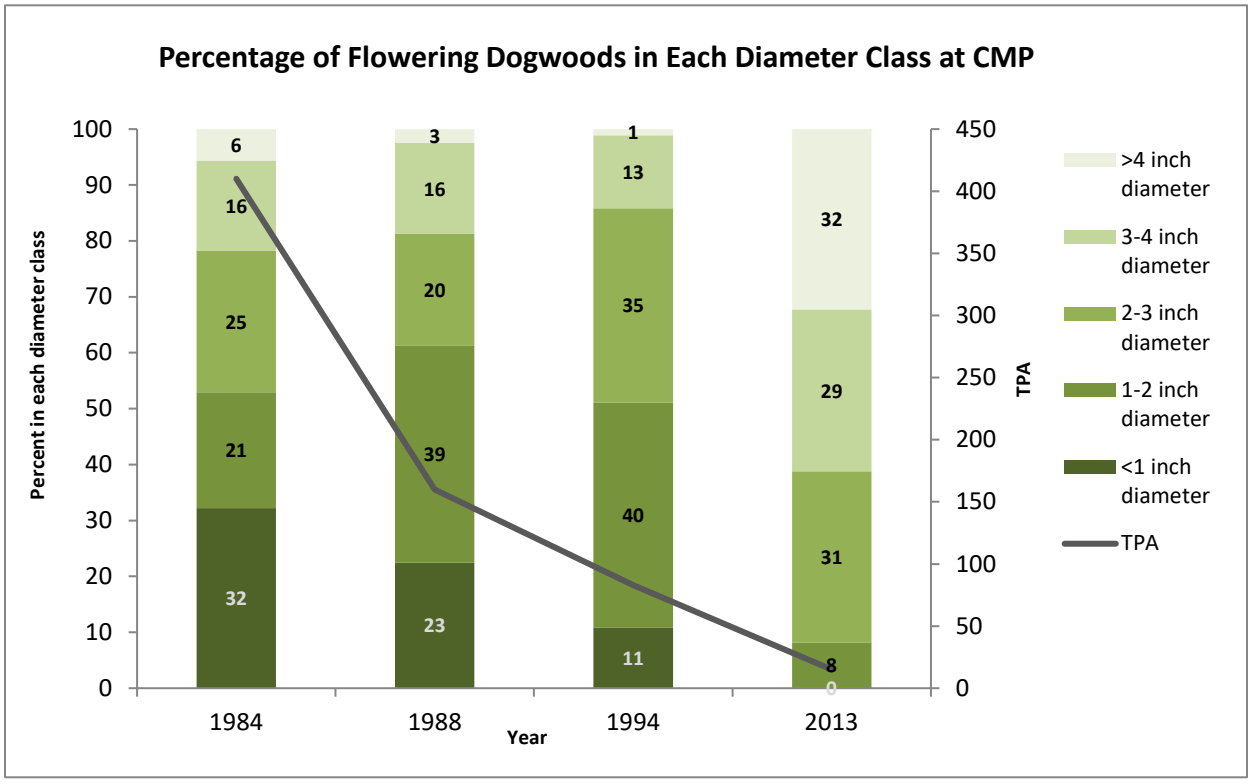

Figure 2. Percentage of flowering dogwoods in each diameter class at Catoctin Mountain Park in 1984 (Mielke and Langdon, 1986), 1998 (Schneeberger and Jackson, 1988), 1994 road plot data (Sherald et al., 1996) and 2013. Diameter data from 2013 includes combined forest and road survey data. All data includes both live and dead trees.

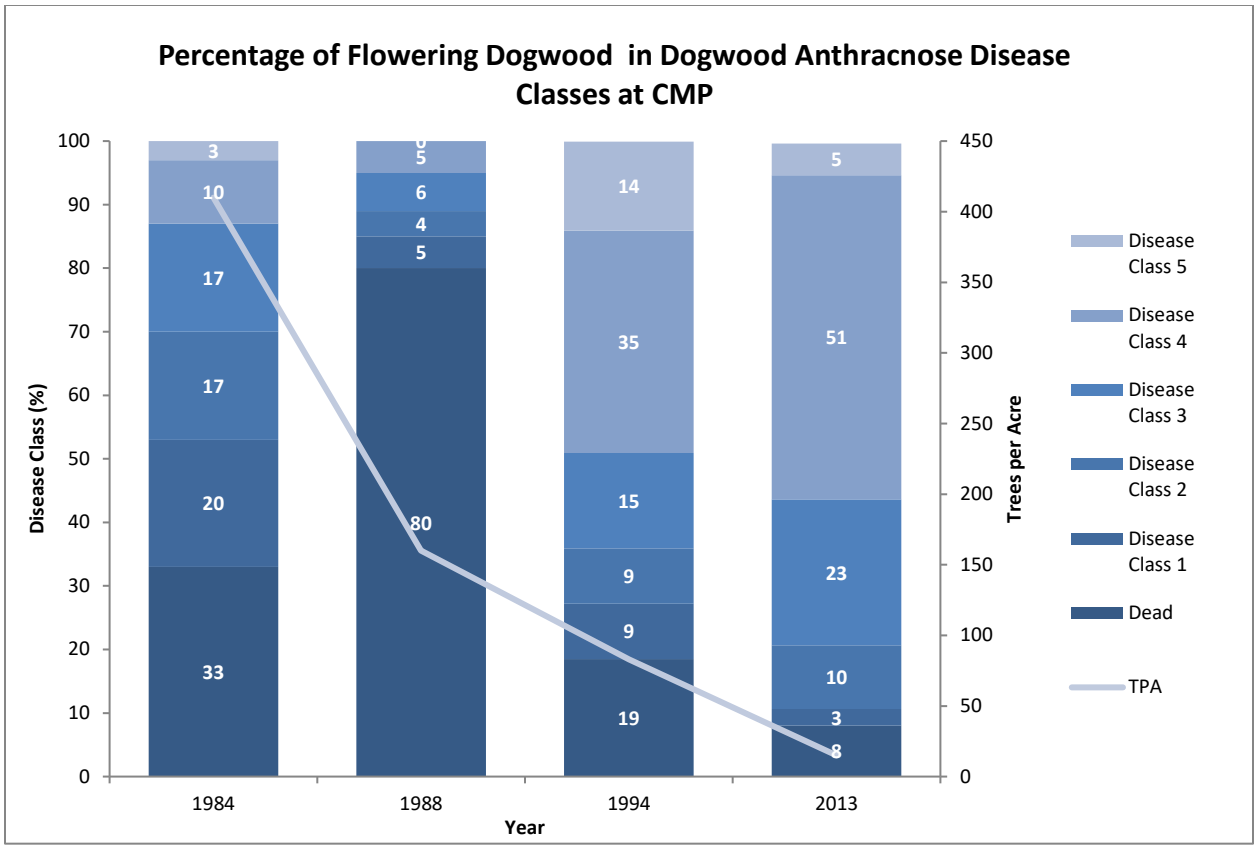

Figure 3. Percentage of flowering dogwoods in each anthracnose disease class at Catoctin Mountain Park in 1984 (Mielke and Langdon, 1986), 1998 (Schneeberger and Jackson, 1988), 1994 road plot data (Sherald et al., 1996) and 2013. Disease class represents percentage of tree exhibiting leaf symptoms and/or dieback: 0 = dead, 1 = > 75% affected, 2 = 51-75% affected, 3 = 26 to 50% affected, 4 = 1 to 25% affected, 5 = healthy. Trees per acre (TPA) included both live and dead trees.

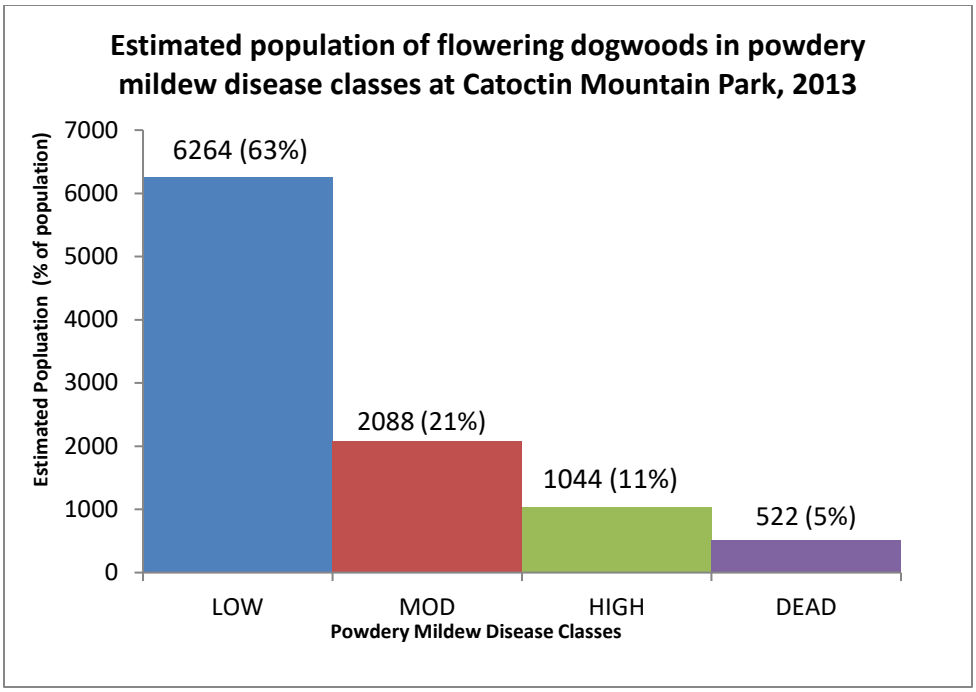

Figure 4. Estimated population of flowering dogwoods in powdery mildew disease classes at Catoctin Mountain Park, 2013. Percentage of tree exhibiting leaf symptoms: none, low=1-33% foliage affected, moderate=34-66% affected high 67-100% infected

Discussion:

As of July 2013, there has been a significant reduction in the number of flowering dogwood trees per acre since the first study that was conducted in 1984 (Figures 1 and 2). Interestingly, an examination of the remaining live trees shows that health of the trees appears to be increasing (Figures 1 and 2). This was probably due to more susceptible trees dying off but could also be due to survival of trees growing in environments less suitable to disease development. Future studies should focus on tracking the health of individual trees versus areas where dogwood are regenerating as this would allow differentiation between susceptible and natural reproduction of resistant dogwood.

Management of flowering dogwood in the presence of dogwood anthracnose requires manipulation of disturbances, host resistance, and intensive husbandry of individual trees. In a forested setting, the only practical management options include host resistance (natural or planting resistant trees) and site manipulation. The relatively high moisture requirements (Britton, 1993) for disease development in combination with the anecdotal relative ease with which dogwood can be located in large clearings (e.g. along roadsides and rock cliffs, in areas of blow-down, etc.) indicates that any form of natural or artificial disturbances should maintain the species. If it were desirable to increase the proportion of dogwood allowing disturbances such as fire or any other disturbance that shifts a mature, closed-canopy to an earlier seral condition would be expected to also result in an increase in flowering dogwood. If desired, high-value trees can be treated individually to promote tree health with many different techniques singly or in combination: irrigation during drought periods, proper mulching, fungicide treatments using labeled chemicals, pruning of diseased host material, and liquid fertilization.

Although many trees appeared healthy, dogwood appears to have been functionally removed from the forested ecosystem at Catoctin Mountain Park by a non-native exotic pathogen, similar to what has

happened across Eastern North America over the past century with other species and disease; such as, American and slippery elm (Dutch elm disease), American chestnut (chestnut blight fungus) and redbay (Laurel wilt). Further losses of Flowering dogwood may be expected at Catoctin Mountain Park and without adequate regeneration, eventual extirpation of susceptible trees may be anticipated.

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